REMARKS

Claims 1-32, 37-39, 41-61, 63-88, 91-97 are currently pending in the present application. In the office action mailed October 6, 2003 ("the Office Action"), claims 14-22, 41-48, 52-61, 64-85, 87, 88, and 92 were rejected under 35 U.S.C. 102(e) as being anticipated by U.S. Patent No. 6,501,483 to Wong *et al.* ("the Wong patent"). Claims 1-13, 23-32, 37-39, 49-51, 63, 86, 91, and 93-97 were rejected under 35 U.S.C. 103(a) as being unpatentable over the Wong patent in view of Don P. Mitchell, "Generating Antialiased Images at Low Sampling Densities," Computer Graphics, Vol. 21, No. 4, July 1987, pp. 65-72 ("the Mitchell reference") and Mark A. Z. Dippe *et al.*, "Antialiasing Through Stochastic Sampling," SIGGRAPH, Vol. 19, No. 3, 1985, pp. 69-78 ("the Dippe reference").

The disclosed embodiments of the invention will now be discussed in comparison to the prior art. Of course, the discussion of the disclosed embodiments, and the discussion of the differences between the disclosed embodiments and the prior art subject matter, do not define the scope or interpretation of any of the claims. Instead, such discussed differences merely help the Examiner appreciate important claim distinctions discussed thereafter.

Embodiments of the present invention are directed to methods and systems for performing multi-sample, anti-aliased rendering of images. The value of a pixel of an image is computed from one or more sample values, each computed at a respective sample point, position, or location. The sampling points, positions, or locations for a pixel are arranged in a sampling pattern. Sample values for a pixel are combined to calculate a value for the pixel. In various embodiments of the present invention, different sampling patterns are applied to different pixels of the image. For example, in one embodiment, different sampling patterns may be applied to alternate pixels along lines parallel to a first axis and/or along lines parallel to a perpendicular second axis. In another embodiment, a repeating sequence of sampling patterns may be applied to consecutive pixels along a row or column. An alternative embodiment provides a sampling pattern having four sample locations within the region of a pixel. The four samples are arranged within the pixel region such that were the pixel region divided into a four-by-four array of sub-regions, the four sample locations would be arranged within the pixel region in a manner such that no two samples are located in the same row, column, or diagonal of sub-regions. A sampling pattern can use only two or three of these four potential positions. In another

embodiment of the present invention, a sampling pattern may be applied repeatedly to a pixel, and the sample values are taken for a pixel and combined and cumulated with previously calculated and stored values. Within a frame the same sampling pattern and the same sampling locations can be used each time a pixel is sampled in order to avoid introducing artifacts.

The Wong patent discloses methods and systems for anti-aliasing using a non-uniform pixel sampling pattern. Examples of the sampling patterns are provided in Figures 2A, 3A, 4A, 5A-5L, and 6A, of the Wong patent. The particular sampling patterns shown in these Figures are described at col. 4, line 3-col. 7, line 17. As disclosed in the Wong patent, the sampling patterns can be applied for anti-aliasing of an image. For example, as shown in Figure 2B, and described at col. 4, lines 31-65, the sampling pattern of Figure 2A is applied to all of the pixels of an image. Figure 2B shows nine pixels of an image arranged in a 3x3 pattern with the sampling pattern of Figure 2A applied to each of the nine pixels. As described in the Wong patent, although the sampling pattern of Figure 2A exhibits "a bias in favor of objects that extend into the upper left and lower right of the pixel area, the composite of multiple pixels in FIG. 2B does not necessarily exhibit such a bias." *See* col. 4, lines 37-40. That is, the sampling pattern of Figure 2A illustrates sampling points that for *one* pixel may not exhibit uniform sample values when an object overlaps the pixel. However, when the same sampling pattern is repeated for *each* pixel of an image formed from the *composite of the pixels*, then the particular sample points will exhibit much greater uniformity, and provide superior anti-aliasing effect. *See* col. 4, lines 40-65.

Alternative sampling patterns, one having six sample points (Figure 3A), and another having six sample points, but over a pixel region divided into 36 sub-regions instead of 16 sub-regions (Figure 4A), are also shown when applied to a composite of pixels (Figures 3B and 4B, respectively). That is, the sampling patterns shown in Figures 3A and 4A are applied to a composite of pixels to demonstrate that greater uniformity can be achieved when the particular sampling pattern is repeated for each pixel of an image. As described in the Wong patent, "although the super-sampling at the pixel level is non-uniform (FIGS. 3A, 4A), the super-sampling pattern relative to an arrangement of multiple pixels is substantially uniform (FIGS. 3B, 4B)." *See* col. 5, lines 8-11.

The Wong patent further describes that the resulting sampling patterns of Figures 3A and 3B exhibit varying horizontal and vertical sampling frequency. Although the same sample pattern is applied to each of the pixels, and the number of sample points in each pixels are the same, the total number of sample points overlapping an edge of an object as it passes over the pixels does not change consistently, and as a result, can produce non-uniform changes in the pixel color. *See* col. 5, lines 21-45. The Wong patent mentions that if a non-uniform pixel change is objectionable, the sampling pattern shown in Figures 4A and 4B can be applied to provide a uniform sampling frequency for object changes or motions in the horizontal and vertical directions. *See* col. 5, lines 49-57.

The Wong patent further describes 24 sampling patterns (*i.e.*, the 12 sampling patterns of Figures 5A-5L, plus the "inverted" patterns for each of those) with respect to Figures 5A-5L at col. 6, lines 2-8, that have uniform horizontal an vertical sampling frequencies. The "inverted" sampling pattern of Figure 5A is applied to a composite of pixels, as shown in Figures 6A and 6B. With respect to the sample pattern of Figures 6A and 6B, the Wong patent discusses that although a uniform horizontal and vertical sample rate is provide by the particular sample pattern, the sample frequency is not uniform in each of the diagonal directions. That is, for an object in motion having an edge passing at an angle with respect to the arrangement of the pixels, the sampling frequency can be different. *See* col. 6, lines 19-65. The Wong patent suggests that if the uniform diagonal sampling frequency is desirable, then the sampling pattern that is applied to the composite of pixels should not be that shown in 6A.

The Mitchell reference discloses the use of a non-uniform sampling pattern for purposes of antialiasing. As described therein, a particular method of non-uniform sampling referred to as "Poisson-disk," provides a distribution of sampling points that can be used to make aliasing noise less conspicuous to a viewer. One approach of simulating true Poisson-disk samples is provided by using the Floyd-Steinberg halftoning algorithm. Another type of non-uniform sampling described in the Mitchell reference is adaptive sampling. In one form of adaptive sampling, the sampling densities vary as a function of image variance. For example, a first basic sampling pattern can be used for most regions, however, in a region where the image has large variations, a different sampling pattern can be used in order to increase the number of

samples in that region. The Mitchell reference further describes a method of measuring the local variance of an image for determining when the different sampling pattern should be applied.

The portion of the Dippe reference cited by the Examiner discloses that a sufficient sampling rate should be selected in order to avoid aliasing. The Dippe reference describes using a signal to noise ratio ("SNR") as a measure of suitable sampling, and further provides different approaches for calculating SNR. Use of adaptive sampling rates is also discussed, with a couple of different methods described in the Dippe reference.

As previously mentioned, claims 1-13, 23-32, 37-39, 49-51, 63, 86, 91, and 93-97 were rejected under 35 U.S.C. 103(a) as being unpatentable over the Wong patent in view of the Mitchell and Dippe references.

Claim 1 is patentable over the Wong patent in view of the Mitchell and Dippe references. Claim 1 recites that a method for calculating values for pixels of an image, comprising calculating sample values for pixels of an image in accordance with a sampling pattern for each pixel, the sampling pattern for consecutive pixels alternating between a first and a second sampling pattern, each sampling pattern defining one or more sampling locations at which sample values are calculated, the sampling locations being relative to a pixel, and determining a value for at least one pixel by combining sample values calculated for the sampling locations for the pixel.

The Examiner has acknowledged that the Wong patent does not teach "the sampling pattern for consecutive pixels alternating between a first and second sampling pattern." *See* the Office Action at page 26. The Mitchell reference, as characterized by the Examiner, "teaches a non-uniform or adaptive sampling patterns with variations in local sampling densities for super-sampling cells or pixel regions or pixels." *Id.* The Examiner further argues that "[i]t would have been obvious to one of ordinary skill in the art to have incorporated the Mitchell's non-uniform or adaptive sampling for super-sampling into the Wong's invention to select sampling patterns for pixels because Wong also teaches non-uniform sampling patterns and non-uniform pixel changes and further teaches that the determination of the appropriate super-sampling pattern to use in [sic] somewhat subjective (citation omitted) and therefore suggesting two different sampling patterns can be selected for consecutive pixels." *Id.*

The Examiner's argument cannot be maintained for at least two reasons: (1) the teachings of the two references would not be combined by those ordinarily skilled in the art because the Wong patent teaches away from using either any of the non-uniform sampling techniques disclosed in the Mitchell reference; and (2) even if the Examiner's characterizations of the Wong patent and the Mitchell reference are assumed to be accurate for the sake of argument, the combined teachings would still not teach or suggest the combined references of claim 1.

As previously discussed, the Wong patent describes using a common per pixel sampling pattern for the pixels of image, where the number of sample points per pixel is less than half of the number of sub-pixel locations for a pixel region. As described therein, there are many potential per pixel sample patterns that can be used. The particular example provided in the Wong patent is the selection of four sample points per pixel for 16 different sub-pixel (in a four-by-four array) locations, where there is only one sample point per row and column of the four-by-four array. The different possible combinations of such a sampling pattern is shown in Figures 5A-5L. The Wong patent further describes that not all of the sampling patterns shown will be suitable for the purpose of sampling. In particular, Figure 6A shows an unsuitable per pixel sample pattern. As applied to a larger region of nine pixels (in a three-by-three array) shown in Figure 6B, it is apparent that using the per pixel sampling pattern of Figure 6A will not provide acceptable results. In contrast, Figure 2A shows a suitable per pixel sampling pattern. As applied to a larger region of nine pixels shown in Figure 2B, the *overall* sampling for the larger region of pixels will provide uniform sampling points, although the sampling points *per pixel* are not uniform. Figures 3 and 4 of the Wong patent are used to illustrate the desirability of choosing a number of sample points per pixel that is a multiple of the total number of sub-pixel locations. In Figure 3A, five sample points of 16 possible sub-pixel locations yields an overall non-uniform sampling rate, shown in Figure 3B. In contrast, Figure 4A shows a per pixel sampling pattern having six sample points for 36 possible sub-pixel locations. As described in the Wong patent, the overall sampling for a larger region, shown in Figure 4B for nine pixels, is uniform.

One ordinarily skilled in the art, would not be motivated to combine the non-uniform sampling methods described in the Mitchell reference with the teachings of the Wong

patent because the non-uniform sampling described in the Mitchell reference is contrary to using the *same* per pixel sampling pattern disclosed in the Wong patent. As previously discussed, the Wong patent clearly describes using the same per pixel sampling pattern for the pixels of an image. In each instance where a particular per pixel sample pattern is illustrated (Figures 2A, 3A, 4A, and 6A), the application of the same per pixel sampling pattern to a larger region of multiple pixels to illustrate the uniformity or non-uniformity of the overall sampling. Mitchell, in contrast, describes non-uniform sampling, a first method using Poisson-disk sampling and another using adaptive sampling. The Poisson-disk sampling inherently produces per pixel sampling patterns that are not the same. It may the case that the same per pixel sampling pattern occurs for the pixels of an image, but this is clearly different than applying the same per pixel sampling pattern for all the pixels of an image, as described in the Wong patent. With respect to the adaptive sampling described in the Mitchell reference, this also is inherently different than applying the same per pixel sampling pattern for the pixels of an image, since the number of samples taken varies as a function of local image variance. Using different sampling patterns, or more specifically, sampling rates, is the rationale behind applying adaptive sampling. Consequently, where adaptive sampling is employed, different per pixel sampling patterns will be used. With respect to the teachings of the Dippe reference, it would also be contrary to one ordinarily skilled in the art to combine with the Wong patent since, as previously mentioned, the Dippe references teaches adaptive sampling as well.

Thus, because the Wong patent teaches applying the same per pixel sampling pattern for the pixels of an image, one ordinarily skilled in the art would not be motivated to combine the teachings of the Mitchell or Dippe references since it is contrary to the fundamental teachings of the Wong patent.

Even if the teachings of the Wong patent and the Mitchell and Dippe references were to be combined, the resulting disclosure would not teach or suggest the combined elements of claim 1. The Examiner argues that the combination of the Wong patent and the Mitchell reference suggests that two different sampling patterns can be selected for consecutive pixels. However, even if this characterization is assumed to be accurate, two different sampling patterns for consecutive pixels is not analogous to alternating between first and second sampling patterns. Alternating means that the first and second sampling patterns are repeated. The Mitchell

reference does not teach alternating first and second sampling patterns since it discloses non-uniform sampling patterns employing Poisson-disk sampling and adaptive sampling. Neither one of these non-uniform sampling techniques would result in alternating first and second sampling patterns. Similarly with the Dippe reference, the adaptive sampling disclosed therein would not provide teachings of alternative first and second sampling patterns either.

For the foregoing reasons, claim 1 is patentable over the Wong patent in view of the Mitchell and Dippe references. Consequently, the rejection of claim 1 under 35 U.S.C. 103(a) should be withdrawn.

Similarly, claims 27, 37, 49, 63, 86, 91, and 93 are patentable over the Wong patent in view of the Mitchell and Dippe references. As previously discussed with respect to claim 1, the combined teachings of the Wong patent and the Mitchell and Dippe references do not teach or suggest the combination of limitations recited by the respective claims. The Examiner has argued that one ordinarily skilled in the art would have been motivated to combine the teachings of the cited references with the Wong patent. However, as previously discussed, the motivation to combine the teachings is lacking because the Wong patent teaches away from applying the non-linear sampling disclosed in the Mitchell and Dippe references. The Wong patent describes using the same per pixel sampling pattern for the pixels of an image in order to obtain overall sampling points. In contrast, the Mitchell and Dippe references disclose non-linear sampling where the sample pattern will be, and preferably so, vary from pixel to pixel. Thus, it is unlikely that one of ordinary skill in the art would combine such contrary teachings.

Moreover, as also previously discussed, even if the teachings of the Wong patent were combined with the Mitchell and Dippe references, it would not teach or suggest the combination of limitations recited by the respective claims. For example, with respect to claim 86, the combined teachings do not teach or suggest an apparatus for sampling in accordance with a sampling pattern alternating per pixel between first and second sampling patterns for consecutive pixels arranged along any given line parallel to the first axis and/or for consecutive pixels arranged along any given line parallel to the second axis. With respect to claim 91, the Wong patent combined with the Mitchell or Dippe references does not teach or suggest an apparatus calculating sample values for pixels in accordance with first and second sampling rates, the sampling rate remaining constant for consecutive pixels arranged along any

given line parallel to the first axis and the sampling rate varying between the first and second sampling rates for consecutive pixels arranged along any given line parallel to the second axis.

For the foregoing reasons, claims 27, 37, 49, 63, 86, 91, and 93 are patentable over the Wong patent in view of the Mitchell and Dippe references. Therefore, the rejection of claims 27, 37, 49, 63, 86, 91, and 93 under 35 U.S.C. 103(a) should be withdrawn.

Claims 2-13, which depend from claim 1, claims 24-26, which depend from claim 23, claims 28-32, which depend from claim 27, claims 38 and 39, which depend from claim 37, claims 50 and 51, which depend from claim 49, claims 65-69, which depend from claim 64, and claims 94-97, which depend from claim 93, are similarly patentable over the Wong patent in view of the Mitchell and Dippe references because of their dependency from an allowable base claim.

Moreover, the claims are patentable because the Wong patent, and the Mitchell and Dippe references fail to teach the combined limitations recited by the respective claim. For example, claim 24 recites that the sampling rate alternates per pixel for consecutive pixels along lines parallel to one or the other axes of the image for at least some of the horizontal or vertical lines of pixels of the image. Clearly none of the references cited by the Examiner teach having the per pixel sampling pattern alternate either per row and/or column of pixels. Similarly, with respect to claim 28, where the pixels of the image are arranged in rows parallel to the first axis and columns parallel to the second axis, and the first and second sampling rates alternate every row of pixels. The Wong patent, and Mitchell and Dippe references do not teach alternating the sampling pattern every row. The Examiner is encouraged to read the language of the claims rather than make gross generalizations with respect to the subject matter of the particular claims, and the relevancy of the art cited.

For the foregoing reasons, claims 2-13, 24-26, 28-32, 38, 39, 50, 51, 65-69, and 94-97 are patentable over the Wong patent in view of the Mitchell and Dippe references. Therefore, the rejection of claims 2-13, 24-26, 28-32, 38, 39, 50, 51, 65-69, and 94-97 under 35 U.S.C. 103(a) should be withdrawn.

As previously mentioned, claims 14-22, 41-48, 52-61, 64-85, 87, 88, and 92 were rejected under 35 U.S.C. 102(e) as being anticipated by the Wong patent.

Claims 14, 41, 52, 64, 70, 87, and 92 are patentably distinct from the Wong patent because the Wong patent fails to teach each limitation in the recited combination of the respective claims. For example, with respect to claim 14, which recites in pertinent part calculating pairs of sample values for pixels of the image in accordance with a plurality of sampling patterns, one sampling pattern per pixel, one pair of sampling points per sampling pattern, the Wong patent fails to describe using a pair of sample values for the pixels of an image as recited in claim 14. The Wong patent merely discloses the sample patterns shown in Figures 1-6, none of which illustrate using pairs of sample values. Also, with respect to claim 52, which recites calculating sample values for pixels of the image in accordance with a plurality of sampling patterns, the Wong patent describes, as previously discussed, the use of the same per pixel sampling pattern for the pixels of an image.

For the foregoing reasons, claims 14, 41, 52, 64, 70, 87, and 92 are patentably distinct from the Wong patent. Therefore, the rejection of claims 14, 41, 52, 64, 70, 87, and 92 under 35 U.S.C. 102(e) should be withdrawn.

Claims 15-22, which depend from claim 14, claims 43-48, which depend from claim 42, claims 53-61, which depend from claim 52, claims 65-69, which depend from claim 64, claims 71-85, which depend from claim 70, and claim 88, which depends from claim 87, are also patentably distinct from the Wong patent based on their dependency from a respective allowable base claim. Additionally, the dependent claims recite a combination of limitations that are not disclosed in the Wong patent. For example, with respect to claim 21, the Wong patent does not teach a per pixel sampling pattern that alternates along at least one row or column of pixels of the image. As previously discussed, the Wong patent only discloses using the same per pixel pattern for the pixels of an image, and the Mitchell and Dippe references, which describe using non-uniform sampling, would not be combined with the teaching of the Wong patent since it would be contrary to the teachings therein. Also, with respect to claim 54, the Wong patent fails to teach a sampling pattern for a given pixel is determined by a calculation based upon the row and/or column containing the pixel. None of the references cited by the Examiner, the Wong patent or the Mitchell and Dippe references, teach this limitation. The Mitchell and Dippe references discuss non-uniform sampling based on Poisson-disk sampling, or adaptive sampling, but none based on the row or column of the pixels. As with the dependent claims rejected under

35 U.S.C. 103(a) (previously discussed), the Examiner is encouraged to read the language of the claims rather than make gross generalizations with respect to the subject matter of the particular claims, and the relevancy of the art cited.

For the foregoing reasons, claims 15-22, 43-48, 53-61, 65-69, 71-85, and 88 are patentably distinct from the Wong patent. Therefore, the rejection of claims 15-22, 43-48, 53-61, 65-69, 71-85, and 88 under 35 U.S.C. 102(e) should be withdrawn.

All of the claims pending in the present application are in condition for allowance. Favorable consideration and a timely Notice of Allowance are earnestly solicited.

Respectfully submitted,

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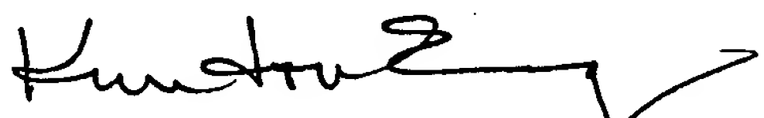

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